DESCRIPTION

DISPLAY PANEL

Technical Field

[0001] The present invention relates to a display panel used in a monitor of a personal computer, a television, or the like, more specifically, a display panel having a no emission type display unit and a back light system.

Prior Art

[0002] In no emission type displays, such as a liquid crystal, a back light system for forming pictures is necessary. However, in the back light system, a power supply for causing a light source to emit light is necessary, and electric waves radiated from this power supply circuit act as noises onto an operation circuit of the no emission type display unit so as to cause picture disturbances such as flickering, stripe drifting and flicker. The troubles become remarkable in high resolution pictures such as high-vision pictures, high speed movies, or displays corresponding to large screens. For example, in liquid crystal displays, electric waves having a frequency of 10 to 100 kHz are radiated from an inverter power supply circuit of their cold cathode fluorescent lighting (CCFL), and the electric waves act as noises to produce a bad effect on the operation circuit of their liquid crystal display unit. Conventionally, a great number of liquid crystal displays are small-sized, and a light source of their back light is arranged on the side face of a liquid crystal display unit and further the cold cathode fluorescent lighting thereof is surrounded by metal. Since electric waves radiated from the light source circuit of the back light are radiated in parallel to their display circuit, the waves produce a small effect on the

display unit. However, on the basis of enlargement of the size of display screens and demands for high intensity, just-downward type back lights, wherein their light source is arranged under a display unit, have been developed, and an effect given to the display unit by electric waves radiated from their back light source circuit has been unable to be ignored since the electric waves radiated from the circuit are emitted perpendicularly to their display unit circuit. The present problem has been becoming a more serious problem on the basis of shifts to larger screens, and higher intensity, which is inevitably required, broader bands, and higher speed movies. As a means for solving a problem similar to this, there is suggested a method of arranging a film on which ITO (a mixture of indium oxide and tin oxide) is vapor-deposited or sputtered (hereinafter referred to as an ITO film) between a display unit and a back light system (see, for example, Japanese Laid-Open Patent Publication No. H7-297591.)

[0003] However, there remain the following problems: the ITO film has a high refractive index and absorptivity so that the light transmittance thereof becomes low; thus, the quantity of light from the back light lowers so that the brightness thereof becomes low. If the thickness of the ITO film is made small, the light transmittance becomes high, but the surface resistivity becomes high at a large ratio. Therefore, if the light transmittance is made high, there is caused a problem that a performance for shielding radiated electric waves is lost. For monitors or televisions, as are compared with conventional liquid crystal displays, the vividness of pictures is the most important quality. Thus, a fall in brightness becomes a serious problem. Furthermore, the ITO film has a yellowish tinge; it is therefore said that the matter that the film changes the color tone of images is also an important problem. It has been desired that these problems are solved. Moreover, it is said, as a problem in practical use, that the price of ITO films is far higher than that of other members and thus the use thereof is restricted.

[0004] The present invention provides a practicable display panel which is small in fall in light quantity from a back light, change in color tone of images, and yellowing, and further which has a display unit that is not affected by electric waves radiated from a back light source circuit.

Disclosure of the Invention

[0005] The present invention is a display panel wherein an electroconductive polymer layer, preferably an electroconductive polymer film on which an electroconductive polymer layer is stacked, is arranged between a display unit of a no emission type display and a light source of a back light system. The polymer film referred to herein may be a thick sheet-form member having a thickness of 500 μm or more besides any ordinary film. It is preferred to use, as the electroconductive polymer, i)a pyrrole, thiophene, furan, selenophene, aniline, para-phenylene or fluorene polymer or copolymer, or a derivative thereof; or ii) a polymer to which solubility or dispersibility is given by introducing a side chain into a thiophene, alkylfluorene, fluorene, para-phenylene, or para-phenylenevinylene polymer or copolymer, or a derivative thereof; or some other polymer.

Brief Description of the Drawings

[0006] Fig. 1 is a schematic view of a display panel which is a structural example of the present invention.

[0007] Fig. 2 is a schematic view of an electroconductive polymer layer having a light diffusion function.

[0008] Fig. 3 is a schematic view of an electroconductive polymer layer having a light diffusion function.

[0009] Fig. 4 is a schematic view of an electroconductive polymer layer having a light diffusion function.

[0010] Fig. 5 is a schematic view of an electroconductive polymer layer having a brightness enhancement function.

Explanation of reference numbers

1 ... display unit of a display panel

2 ... optical film unit of a back light system of the display panel

3 ... a light source of the back light system of the display panel

4 ... reflective film unit of the back light system of the display panel

5 ... electroconductive polymer layer

6 ... resin layer made mainly of an electroconductive polymer

7 ... polymer film

8 ... light diffusion layer

9 ... brightness enhancement layer

Best Modes for Carrying Out the Invention

[0011] The present invention will be described in detail by use of a schematic view, Fig. 1 of a just-downward type lamp system which is a structural example of the display panel of the present invention. The display panel is composed of a display unit (1), an optical film unit of a back light system (2), a light source (3), a reflective film unit (4), and an electroconductive

polymer layer (5). In the case of a display panel using liquid crystal, the display unit (1) is usually composed of a polarizing plate (protective layer/TAC/PVA-iodine complex/TAC/adhesive layer/optical compensating plate), a liquid crystal unit (glass/color filter/ITO film/oriented film/liquid crystal/oriented film/TFT circuit/glass), and a polarizing plate (optical compensating plate/adhesive layer/TAC/PVA-iodine complex/TAC). The optical film unit of the back light system (2) is usually made of the following: light diffusion film/brightness enhancement film/brightness enhancement film (lens film)/light diffusion film, or the like. As the light source (3), a cold cathode fluorescent lighting (CCFL) is usually used. A contrivance is made in such a manner that light rays advancing in the direction opposite to the optical film unit (2), out of light rays radiated from the light source (3), are reflected on the reflective film unit (4) and radiated into the optical film unit to make the brightness high. In the display panel of Fig. 1, the electroconductive polymer layer (5) is arranged between the light source (3) and the optical film unit (2), so as to make it possible to shield radiated electric waves from the light source (3) and largely decrease the radiated electric waves emitted into the display unit (1). The position of the electroconductive polymer film (5) is not limited to the position shown in Fig. 1, and the film (5) may be set up between the optical film unit (2) and the display unit (1), or set up between the respective films of the optical film unit (2). Furthermore, the film (5) may be compounded with the respective films of the optical film unit (2), which will be described later.

[0012] The electroconductive polymer layer referred to in the present invention is an object having a resin layer made mainly of an electroconductive polymer.

[0013] In the case that the electroconductive polymer is colored, the light transmittance thereof may fall to decrease the brightness of light radiated into the display unit (1) if the resin layer is made thick. Moreover, the electroconductive polymer itself is poor in flexibility. For

these reasons, it is preferred that the electroconductive polymer layer is an electroconductive polymer film wherein a resin layer made mainly of an electroconductive polymer is stacked on at least one face of a polymer film. The use of the electroconductive polymer film causes the step of the display panel fabrication easier and heightens stability against bending generated by the shift of the display panel, and other effects.

[0014] The polymer film is not limited to any especial kind, and is preferably a film made of a resin having a high transparency, such as polycarbonate, acrylic resin, or a polyester resin such as polyethylene terephthalate or polyethylene naphthalate. Of these, a polyethy-lene terephthalate film, which has heat resistance and an excellent transparency, is more preferred. In order to improve the adhesiveness thereof to the electroconductive polymer, it is preferred to subject the polymer film beforehand to surface treatment, such as coating with an adhesive resin or discharge treatment, in the step of forming the film or after the film is formed. The electroconductive polymer layer may be stacked by coating after the polymer film is formed, or may be stacked by coating, coextrusion, or the like in the step of forming the polymer film (in the formation step). The polymer film may be a layer having another function such as a light diffusion action within the scope of the object of the present invention. Another layer may be stacked on the polymer film.

[0015] In order to obtain an effective shield performance, the surface resistivity of the electroconductive polymer is 1×10^4 Ω/□ or less, preferably 5×10^3 Ω/□ or less, more preferably 2×10^3 Ω/□ or less. In order to raise the brightness of images, it is preferred that the total light transmittance is higher. The total light transmittance is 80% or more, preferably 85% or more, more preferably 90% or more. The shield effect is better as the surface resistivity is lower, but in order to make the surface resistivity low, it is necessary that the film thickness of the resin layer

made mainly of the electroconductive polymer is made large. Thus, there is caused a problem that the light transmittance lowers to make low the brightness of light radiated into the display unit (1). It is therefore preferred to set the surface resistivity of the electroconductive polymer layer and the total light transmittance to 1×10^4 Ω/□ or less and 80% or more, respectively, more preferably 5×10^3 Ω/□ or less and 85% or more, more preferably 2×10^3Ω/□ or less and 90% or more by the selection of the electroconductive polymer and appropriate adjustment of the thickness.

[0016] In order to decrease a change in color tone of light from the light source, it is preferred to select the electroconductive polymer and make appropriate the film thickness of the resin layer made mainly of the electroconductive polymer so as to set the spectral light transmittance at 400 nm wavelength to 85% or more. Electroconductive polymer is described in detail in "Account about Electroconductive Polymer" (written by Katsumi Yoshino, and published by the Nikkan Kogyo Shimbun, Ltd.), "Electroconductive Polymer" (edited by Naoya Ogata, and published by Kodansha Scientific), or Handbook on Conducting Polymer (written by Skotheim T. D., and published by Dekker Co.).

[0017] The electroconductive polymer of the present invention is not limited to any kind, and is preferably one or more selected from polypyrrole, polythiophene, polyfuran, polyselenophene, polyaniline, poly-p-phenylene, polyfluorene or derivatives thereof, or copolymers of monomers of these, in view of transparency, electroconductivity, and flexibility.

[0018] The resin layer made mainly of the electroconductive polymer of the present invention can be formed by a method of performing electrochemical polymerization or vapor-depositing the electroconductive polymer directly onto a film on which Pd, Pt or the like is sputtered, or some other method. The resin layer made mainly of one or more electrocon-ductive

polymers selected from derivatives of polythiophene, polyalkylfluorene, polyfluorene, poly-p-phenylene and poly-p-phenylenevinylene which each have solubility or dispersibility in a solvent or water by the introduction of a side chain, or copolymers of monomers of these is preferable since the resin layer is excellent in transparency and electroconductivity and further can be applied to a polymer film or a film having a different function so as to make it possible to form uniformly an electroconductive polymer film having an appropriate thickness. In particular, a polythiophene resin layer made mainly of an electroconductive polymer comprising polyethylenedioxythiophene, in particular, polyethylenedioxythiophene and polystyrenesulfonic acid is most preferable for the following reasons: the resin layer can easily be dissolved or dispersed in water or a solvent so as to be able to be easily applied to a polymer film; and further a film which is particularly high in transparency and electroconductivity can be formed. The method for preparing the resin solution wherein the electroconductive polymer comprising polyethylenedioxythiophene and polystyrenesulfonic acid is dissolved or dispersed in water or a solvent is suggested in USP No. 5300575, JP-A No. H9-31222, and WO 02/067273 A1.

[0019] The thickness of the resin layer obtained after the water-soluble resin solution or the solution of the resin dissolved or dispersed in the solvent is applied and dried is preferably 60 nm or more and 300 nm or less. If the thickness is less than 60 nm, the surface resistivity is too high to give a sufficient effect of shielding radiated electric waves. If the thickness is more than 300 nm, the light transmittance becomes too low.

[0020] Light can be diffused and projection of the light source watching from front side of display panel can be decreased, by the addition of particles such as polystyrene particles or acrylic resin particles to the resin layer made mainly of the electroconductive polymer. Furthermore, it is possible to obtain the following effects since the skid resistance of the resin

layer is reduced: an effect that at the time of cutting the film/sheet into a display screen size, the cut films or sheets can easily be stacked; and other effects.

[0021] An electroconductive polymer layer wherein a resin layer made mainly of the electroconductive polymer of the present invention is applied onto a light diffusion film (for example, Fig. 3) makes it possible that one of the films is removed from the structure of the display panel of Fig. 1, and has an advantage that a reduction in the brightness of light radiated into the display unit (1) is decreased and the number of steps for the fabrication is decreased. The light diffusion layer can also be stacked on an electroconductive polymer film (for example, Figs. 2 to 4). The resin composition of the light diffusion layer is not limited, and can be formed by dispersing particles, such as acrylic resin particles, styrene-based resin particles, nylon resin particles, silicone resin particles, urethane-based resin particles or ethylene-based resin particles, having an average of particle diameters of 10.0 to 50.0 μm, and a coefficient variance of particle diameter distribution of less than 50.0%, into a layer of a resin such as acrylic resin, polyester resin, urethane-based resin, styrene-based resin, vinyl-based resin, ethylene-based resin, cellulose resin, amide-based resin, imide-based resin, phenol-based resin, silicone resin or fluorine-contained resin. In particular, acrylic resin, particularly, acrylic polyurethane resin is preferable since the resin is good in transparency. For the electroconductive polymer layer on which the light diffusion layer is stacked, it is preferred to adjust the total light transmittance thereof and the haze thereof to 70% or more and 80% or more, respectively, in order to decrease a reduction in the brightness.

[0022] As illustrated in, for example, Fig. 5, it is also permissible to form an electroconductive polymer layer onto the face opposite to a brightness enhancement layer made of a prism of a brightness enhancement film or the like.

[0023] The development of electroconductive polymer to a shield purpose has been investigated, but the electroconductivity is low so that a sufficient shield effect cannot be obtained; therefore, investigation for improving the electroconductivity by doping has been continued. However, there is a problem that if the amount of the doping is made large, the electroconductive polymer loses flexibility so that the polymer cannot be worked.

[0024] In the past, investigation was made to develop electroconductive polymer to articles for electromagnetic interference shield. However, the electroconductivity thereof is far lower than that of metal. Consequently, necessary performance has not been attained and the articles have not been made practicable. However, it has been found out that in the present display panel, electroconductive polymer can exhibit its property sufficiently for the following reasons: the polymer produces a sufficient shield effect even if it has a low electroconductivity since the frequency of the power supply is as low as 10-100 kHz; and the polymer can maintain necessary transparency.

[0025] The electroconductive polymer film/sheet can be produced at a rate of several tens of meters per minute by coating; therefore, it is said that primitive costs thereof are lower and the possibility of actual use thereof is higher as the film/sheet is compared with ITO films produced by vapor deposition or sputtering at a rate of several meters per minute, using vacuum equipment.

[0026] The present invention is not limited to a display panel of a just-downward type back light system, and can be applied to any display panel of an edge light type. For example, in the case that the electroconductive polymer layer is set on a light conducting plate, an effect of electric waves radiated from the light source can be made smaller.

Examples

[0027] The present invention will be described specifically and in detail by way of examples hereinafter.

[Evaluation method]

1. Surface resistivity: it was measured by the four-terminal method

2. Total light transmittance: it was measured in accordance with JIS-K 7105.

3. Spectral light transmittance at 400 nm wavelength: it was measured, using a spectrophotometer U-3410 (manufactured by Hitachi Ltd.).

4. Shield effect: values at 1 MHz, 500 KHz and 300 KHz were extrapolated from data measured by the KEC method of (Corp.) Kansai Electric Industry Development Center, and then a value at 50 KHz was estimated.

5. Effect as a display panel (picture evaluation): A 20-inch liquid crystal television manufactured by Sharp Corp. was decomposed, and an electroconductive polymer film was set instead of an ITO film integrated therein. Thereafter, the television was again fabricated, and test pattern signals were sent thereto so as to observe generation of noises, disturbances of pictures, and white balance.

Example 1

[0028] One face of a polyethylene terephthalate film of 125 μm thickness was coated with a water dispersion of an electroconductive polymer made of polyethylene-dioxythiophene and polystyrenesulfonic acid so as to yield a film (trade name: Orgacon TM EL-1500, manufactured

by Agfa-Gevaert N. V.) on which the electroconductive polymer of 96 nm thickness was stacked.

[0029] Physical properties, and a picture evaluation result when the film was set to replace the ITO film put in the backlight system of the liquid crystal display therewith are shown in Table 1. The film was sandwiched between metal springs, and the metal springs were connected to a chassis through leads so as to connect the film to the ground. As shown in Table 1, in the display panel in which this film was set, pictures were not skewed, the white balance thereof was within a fine adjustment range, and yellowing was also slight.

Example 2

[0030] The rear face (the face opposite to the electroconductive polymer layer face) of the film of Example 1 was coated with 170 parts of an acrylic polyol resin (solid content: 50%), 30 parts by weight of an isocyanate curing agent resin (solid content: 60%), and 200 parts of a resin solution having an average particle diameter of 18 μm and a coefficient variance of 25.6% (solvent: n-butyl acetate/MEK), so as to yield an electroconductive polymer film having a light diffusion layer the thickness of which was 36 μm after the layer was dried. This film was evaluated in the same way as in Example 1, and the results are shown in Table 1. As shown in Table 1, in the display panel in which this film was set, pictures were not skewed, the white balance thereof was within a fine adjustment range, and yellowing was also slight.

[0031] For reference, this film was set as follow: the light diffusion film and the ITO film at the lower stage of the optical film system (2) were taken off, and the above-mentioned film was set instead thereof.

Comparative Examples 1 and 2

[0032] ITO was sputtered onto a polyethylene terephthalate film of 125 μm thickness while the surface resistivity thereof was controlled so as to be 330Ω/□. The ITO of the present film was coated with a fluorine-contained resin so as to yield an ITO film having an antireflective layer the thickness of which was 0.1 μm after the layer was dried. This polyethylene terephthalate film was evaluated in the same way as in Example 1, and the results are shown in Table 1.

Examples 3, 4, 5 and 6, and Comparative Examples 3 and 4

[0033] In the process of producing the film, a polyester resin copolymerized with styrenesulfonic acid was applied and stacked onto one face of a polyethylene terephthalate film, then the film was drawn, so as to yield a polyester film of 125 μm thickness (manufactured by Toray Industries, Inc.). Then water dispersions of an electroconductive polymer made of polyethylenedioxythiophene and polystyrenesulfonic acid (trade name: Orgacon TM EL-1500, manufactured by Agfa-Gevaert N. V.), each polymer having different resistivity, was applied onto the polyester film, so as to form a film. This film was set to replace the ITO film put in the back light system of the liquid display in the same way as in Example 1 therewith. Results of the evaluation of pictures at this time are shown in Table 1. The thickness of each of the electroconductive polymer layer was as follows: Example 3: 80 nm, Example 4: 50 nm, Example 5: 200 nm, Example 6: 280 nm, Comparative Example 3: 30 nm, and Comparative Example 4: 400 nm.

Example 7

[0034] In the process of producing the film, a polyester resin copolymerized with styrenesulfonic acid was applied and stacked onto one face of a polyethylene terephthalate film, then the film was drawn, so as to yield a polyester film of 125 μm thickness (manufactured by Toray Industries, Inc.). A solution consisting of 100 parts by weight of solid contents of a water dispersion of an electroconductive polymer made of polyethylene-dioxythiophene and polystyrenesulfonic acid (trade name: Orgacon TM EL-1500, manufactured by Agfa-Gevaert N. V.) and 0.2 part by weight of solid contents of a water dispersible silica sol (trade name: Snow Tex (transliteration) OL, manufactured by Nissan Chemical Industries, Ltd.) was applied onto the polyester film, so as to form a film wherein the thickness of the electroconductive polymer layer was 126 nm. This film was evaluated in the same way as in Example 3, and the results are shown in Table 1.

Examples 8 and 9

[0035] In a vacuum of 0.3 Pa pressure, electric current was caused to flow into a rectangular parallelepiped carbon crucible which had a rectangular parallelepiped groove and was filled with polythiophene (Example 8) or polypyrrole (Example 9) so as to heat the carbon crucible, thereby vaporizing the polythiophene or the polypyrrole so as to be vapor-deposited onto one face of a polyethylene terephthalate film of 125 μm thickness. Properties of these films, wherein the electroconductive film was stacked (vapor-deposited), were evaluated in the same way as in Example 3, and the results are shown in Table 2.

Industrial Applicability

[0036] The display panel of the present invention, wherein a film/sheet on which an electroconductive polymer layer is stacked, is small in fall in brightness, change in color tone, and yellowing, and further disturbance of pictures is not generated.

Table 1

		Examples							Comparative Examples			
		1	2	3	4	5	6	7	1	2	3	4
Electroconductive polymer		Polyethylenedioxythiophene and polystyrenesulfonic acid						The same as the left + colloidal silica	ITO	Not formed	Polyethylenedioxythiophene and polystyrenesulfonic acid	
Light diffusion layer		Not formed	Formed	Not formed								
Surface resistivity (Ω/□)		1190	1170	1980	4990	650	560	960	700 (Before supply of antireflective layer: 330)	10^{12} or more	82000	420
Shield effect (db)		63	63	-	-	-	-	-	65	0	-	-
Total light transmittance (%)		91.0	80.2	92.0	93.5	86	82	86	88.5	93	92	68
Spectral light transmittance at 400 nm wavelength (%)		90.5	79.5	-	-	-	-	-	84.0	-	-	-
Haze (%)		1.8	86.7	-	-	-	-	2.2	2.2	0.9	-	-
Picture evaluation	Noises and image skew	Neither noises nor skew *1)		Slight noises and skew *2)		No noises			Neither noises nor skew *3)	Noises, generated		No noises
	White balance	Able to be adjusted within white balance adjusting range				-	-	-	Slightly reddish within white balance adjusting range	-	-	-

*1) Noises were not generated, and no skew of images was recognized in a check board pattern. However, when no electroconductive polymer film or ITO film was set up, stripes (noises) in the vertical direction at a pitch of 3-4 mm drifting in the lateral direction were generated and the check board pattern was distorted.

*2) In the case that pictures were projected for a long time, pale short noises slightly made their appearance on occasion, and further the check board pattern was sometimes distorted. (Each of them did not come in sight if it was not watched near it with attention.)

*3) Noises were not generated, and further no skew of images was recognized in a check board pattern. However, the check board pattern was slightly distorted in accordance with the manner of sandwiching the metal spring.

Table 2

		Examples	
		8	9
Electroconductive polymer		Polythiophene	Polypyrrole
Light diffusion layer		Not formed	
Surface resistivity (Ω/□)		4200	6500
Shield effect (db)		-	-
Total light transmittance (%)		86	80
Spectral light transmittance at 400 nm wavelength (%)		-	-
Haze (%)		-	-
Picture evaluation	Noises and image skew	Slight noises and skew *2)	
	White balance	-	